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■ **Equipment for:**

- Magnetic Recording
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BRUSH 6 ELECTRONICS

OPERATING INSTRUCTIONS FOR

HIGH GAIN D. C. AMPLIFIER

Model BL-550

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MP MASTER

MA30161

WARRANTY

We warrant each instrument manufactured by Brush Electronics Company to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and replacing any defective parts thereof (except pens, tubes, fuses and batteries).

This warranty is effective for one year after delivery to the original purchaser, when the instrument is returned transportation charges prepaid by the original purchaser, and which upon our examination proves to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at our current rate. In this case, an estimate will be submitted before the work is started.

Warranty card enclosed with shipment must be returned to establish warranty.

■ Claim for damage in Shipment

The instrument should be examined as soon as it is received. If it is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained from the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number, type number and serial number when referring to this instrument for any reason.

■ If any fault develops, the following steps should be taken:

1. Notify our Customer Service Department, 3405 Perkins Avenue, Cleveland 14, Ohio, giving full details of the difficulty, and include the model number, type number and serial number. Upon receipt of this information, we will give you service instructions or issue a material return authorization card.

2. You may request any necessary instrument packaging by telling us what cartons you need. These will be sent to you no charge.

3. Upon receipt of shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the warranty.

SHIPPING

All shipment of instruments should be made via Railway Express.

PLEASE DO NOT HESITATE TO CALL ON US

BRUSH ELECTRONICS COMPANY

DIVISION OF CLEVITE CORPORATION

3405 PERKINS AVENUE • CLEVELAND 14, OHIO

HIGH GAIN D.C. AMPLIFIER Model BL-550

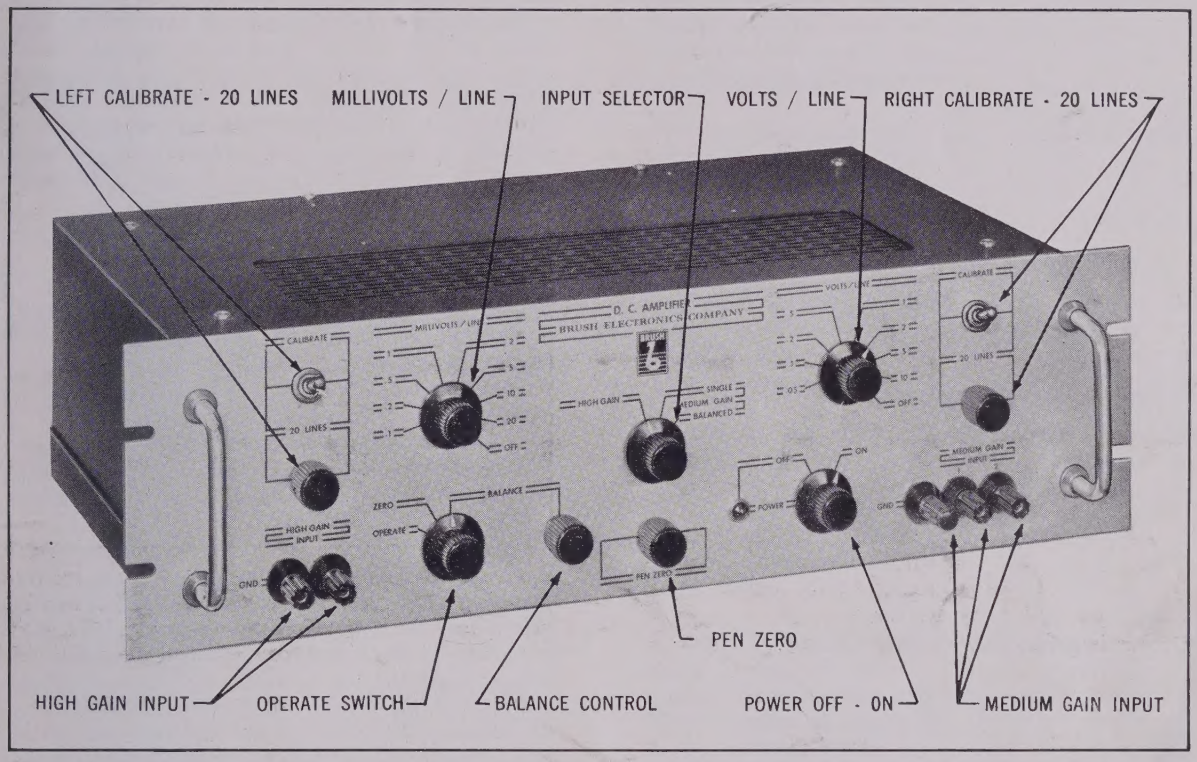

Fig. 1. Brush High Gain D.C. Amplifier Model BL-550.

The Brush High Gain D.C. Amplifier Model BL-550 is a low drift, very high gain, general purpose d.c. amplifier designed for laboratory or field instrumentation, particularly when used in connection with a matching Brush Oscillograph. A high degree of freedom from drift is inherent in this unit. A feedback circuit consisting of a chopper and a high gain a.c. amplifier contribute to stability. The unit will accept a wide range of signals (from 100 microvolts to 500 volts). The input impedance is 1 megohm. A high gain single ended input, and a medium gain balanced or single ended input, as well as two attenuators, add flexibility.

This High Gain D.C. Amplifier will fit a standard 19″ rack or may be mounted in a specially designed Brush Portable Case Model BL-380 for semi-permanent, table-top applications.

SPECIFICATIONS

AS A HIGH GAIN D.C. AMPLIFIER

Maximum sensitivity	100 microvolts per chart line.
Measurement range	100 microvolts to 0.8 volt.
Zero line stability	Better than 50 microvolts per hour, in relation to input, after one hour warmup.
Input impedance	1 megohm (single ended only).
Attenuator steps	.1, .2, .5, 1, 2, 5, 10, and 20 millivolts per chart line.
Calibration	2.0 millivolts signal derived from internal mercury cell.
Noise	Less than 35 microvolts in relation to input.

AS A MEDIUM GAIN D.C. AMPLIFIER

Maximum sensitivity	50 millivolts per chart line.
Measurement range	Single ended input—.050 volt to 400 volts. Balanced input—.050 volt to 20 volts. Maximum ±10 volts each terminal to ground.
Zero line stability	¼ line of chart paper per hour. (Not affected by power line fluctuations between 105 and 125 volts or between 95 and 115 volts.) Total drift over an eight hour period not more than ½ line of chart paper.

Input impedance..... 1 megohm (single ended), and 900K ohms (balanced).

Attenuator steps..... .05, .1, .2, .5, 1, 2, 5, and 10 volts per chart line.

Calibration..... 1.0 volt signal derived from the same internal mercury cell as is used in connection with the High Gain Amplifier.

Signal expander..... A pen positioning control is provided. Permits balancing out the d.c. or static component of a complex signal up to the equivalent of 200 lines either side of chart center, except when Medium Gain-Balanced input is used.

GENERAL (common to both amplifiers)

Frequency response..... Flat from d.c. to 100 cps when matched with Brush Oscillographs. An adjustment is provided for flat response within 3 db from d.c. to 5kc for use with oscilloscopes or for similar applications.

Output impedance..... Approximately 50 ohms.

Output voltage..... 30 volts. Because of bridge type output circuit, output terminals are operated at 30 volts above chassis.

Output current..... 20 ma into 1500 ohms.

Input power required... 105 to 125 volts (or 95 to 115 volts), 60 cps, 80 watts. See ROUTINE ADJUSTMENT and MAINTENANCE.

Fuse..... 2 amp, 250 volts, type 3AG.

Tubes..... High Gain Amplifier: 1 - 12AY7 and 3 - 12AT 7WA.
Correction Amplifier: 1 - 12AT7WA and 1 - 5751.
Pen Drive Amplifier: 1 - 5751, 2 - 12AT7WA and 2 - 5687's.
Power Supply: 1 - 0A2, 1 - 6X4, 1-6080, 1-5751 and 1-3TF4.

Dimensions..... Standard panel: 19" wide x 5¼" high x ¼" thick. Depth: 10¾" (with connectors 12½").

Net weight..... 22 pounds.

Shipping weight..... 28 pounds.

INSTALLATION

Two types of mounting are available, rack or portable case. Installation of the High Gain D.C. Amplifier in a standard 19" rack (customer supplied) is simply a matter of placing the instrument in the rack and fastening it in position with four screws through the front panel. This is a permanent installation and designed for use with other rack mounted instruments.

For maximum portability the Brush Portable Case Model BL-380, (20⅛" wide, 6⅜" high and 10⅜" deep, with a dark grey metallic finish) is recommended. When the High Gain D.C. Amplifier and the Portable Case are purchased together the amplifier is installed in the case at the factory. If purchased separately, installation instructions are furnished with the Portable Case.

NOTE:

THE OUTPUT TERMINALS OF THIS AMPLIFIER ARE 30 VOLTS ABOVE CHASSIS. THEREFORE, SOME OF THE EARLIER BRUSH OSCILLOGRAPHS, Models BL-201, BL-202, BL-221, AND BL-222, MAY REQUIRE THE REMOVAL OF AN EXISTING PENMOTOR LEAD TO THE CHASSIS. ALL BRUSH OSCILLOGRAPHS, Models BL-206 AND BL-208, MUST BE CONVERTED FOR USE WITH THIS AMPLIFIER. SEE BELOW.

All other Brush Oscillographs need no conversion. Present owners of the "BL-200 series" of oscillographs may determine if the penmotor coil of their particular oscillograph is connected to the chassis by disconnecting the input cable from the oscillograph, turning the ON-OFF switch to "ON", and measuring the resistance from each of the two large pins of the four prong input connector to the oscillograph chassis. If the resistance is infinite, the oscillograph will operate satisfactorily with the High Gain D.C. Amplifier. If the resistance between either of the two large pins and the chassis is found to be zero (0) or about 1500 ohms, any connection from the penmotor leads to the chassis (usually found at the input socket of the oscillograph) must be removed.

All Brush Oscillographs, Models BL-206 and BL-208, must be converted for use with the High Gain D.C. Amplifier. The Brush Customer Service Department will be very glad to supply the information to make this conversion.

When operating the Amplifier Model BL-550 in the MEDIUM GAIN-BALANCED position, the signals to be recorded must be checked to determine that the inphase component is no greater than ± 10 volts.

CONTROLS and CONNECTORS

The controls and connectors on the front panel are as follows:

AS A HIGH GAIN D.C. AMPLIFIER

LEFT CALIBRATE-
20 LINES..... Continuously variable gain control for calibrating the amplifier-oscillograph combination when operating the amplifier in the high gain position, using an internal mercury cell as a reference voltage.

MILLIVOLTS/LINE..... Step control to attenuate input signal to the high gain amplifier.

HIGH GAIN INPUT..... GR type terminals for high gain single ended input. Terminal to the left is ground and is so marked on the panel.

OPERATE SWITCH..... Three position switch. "OPERATE" is normal operating position; "ZERO" grounds the high gain section, thus allowing the pen trace to be centered on the chart paper by means of the PEN ZERO control; "BALANCE" position operates in conjunction with the BALANCE CONTROL for internal balance of the high gain section.

BALANCE CONTROL .... Operates in conjunction with the OPERATE SWITCH for internal balance of the high gain section.

AS A MEDIUM GAIN D.C. AMPLIFIER

RIGHT CALIBRATE-
20 LINES..... Continuously variable gain control for calibrating the amplifier-oscillograph combination when operating the amplifier in the medium gain position, using the same internal mercury cell as the LEFT CALIBRATE-20 LINES control.

VOLTS/LINE..... Step control to attenuate input signal to medium gain amplifier.

MEDIUM GAIN INPUT GR type terminals for medium gain, single ended or balanced input signal. Terminal to the left is ground and is so marked on panel.

GENERAL

INPUT SELECTOR..... Selector switch used to match amplifier to the particular level of input signal being used. (High gain with single ended input, or medium gain with single ended or balanced input.)

PEN ZERO..... Adjusts pen to desired position on chart paper, except for medium gain-balanced input.

POWER OFF-ON..... "ON-OFF" switch.

The controls and connectors on the rear panel are as follows:

NARROW COMP..... Frequency compensator for matching penmotor. See ROUTINE ADJUSTMENT and MAINTENANCE.
(narrow compensator)

BROAD COMP..... Same as above.
(broad compensator)

TUBE ADJ..... To be used only in case of tube replacement. See ROUTINE ADJUSTMENT and MAINTENANCE.
(tube adjustment)

POWER Input..... Connects power source to amplifier (2 pin recessed male connector).

OUTPUT..... Connects amplifier output to oscillograph or other equipment (6 pin female AN connector).

MEDIUM GAIN INPUT. This connector is in parallel with the MEDIUM GAIN INPUT terminals on the front panel. Pin "A" is in parallel with "GND" (ground); pin "B" is in parallel with INPUT 1; pin "C" is in parallel with INPUT 2. (3 pin male AN connector.)

GRID CURRENT..... Neutralizes the effect of the grid current in the input stage of the high gain amplifier section.

SIGNAL BAL..... Adjusts the correction feedback ratio of the high gain section of the amplifier.
(signal balance)

PLATE ADJ..... Adjusts the output d.c. level of the high gain section of the amplifier.
(plate adjustment)

* * * * * *

OPERATING PROCEDURE

The following procedures will consider three different and distinct operating conditions and in this order, namely; medium gain with balanced input, medium gain with single ended input, and high gain with single ended input. Selection as to the use of the high or medium gain input terminals is based upon the input voltage. The high gain input terminals should be used for input voltages below 0.4 volt; while the medium gain input terminals should be used for input voltages in the range between 0.4 volt and 500 volts. It is recommended that the medium gain input terminals be tried first if the input voltage is not known. All three of the above conditions have a common setup. To make this setup proceed as follows:

1. Turn POWER OFF-ON switch to "OFF".
2. Turn *both* LEFT CALIBRATE-20 LINES and RIGHT CALIBRATE-20 LINES controls *counterclockwise* as far as possible.
3. Turn *both* the MILLIVOLTS/LINE and the VOLTS/LINE selectors to "OFF".
4. Turn OPERATE SWITCH to "OPERATE".
5. Turn PEN ZERO *counterclockwise* as far as possible. Then *clockwise* 5 full turns. This will be approximately the center of this 10 turn control.
6. Connect the oscillograph to an appropriate power source.
7. Turn the oscillograph ON-OFF switch to "ON".
8. Center the pen on the chart paper by means of the pen centering lever of the oscillograph.
9. Turn the oscillograph ON-OFF switch to "OFF".
10. Connect the amplifier to the oscillograph.

MEDIUM GAIN—BALANCED INPUT

For medium gain, balanced input operation, complete the preliminary setup as explained above and proceed as follows:

1. Turn the INPUT SELECTOR to the MEDIUM GAIN-BALANCED position.
2. Connect the amplifier to an appropriate power source.
3. Turn the POWER OFF-ON switch to "ON". Allow the amplifier 10 to 15 minutes to warm up.
4. Turn the oscillograph to "ON". If necessary zero the pen trace to the center of the chart paper by means of the TUBE ADJ (tube adjustment) on the rear panel.
5. Depress the RIGHT CALIBRATE switch and adjust RIGHT CALIBRATE-20 LINES control for 20 lines of pen deflection.
6. Release RIGHT CALIBRATE switch.
7. Connect the signal input to the amplifier by means of either the front panel (GR) terminals or the rear panel (AN) connector. When connecting a balanced input signal at the front panel, the leads must be connected to the MEDIUM GAIN INPUT 1 and 2 terminals. When connecting a balanced input signal at the rear panel, the leads must be connected to pins "B" and "C" of the rear panel AN connector. (Pin "A" is parallel to the GR terminal marked "MEDIUM GAIN-GND" on the front panel, and is not to be used for balanced input signals.)
8. Adjust VOLTS/LINE selector to desired sensitivity. Each successive step in a *counterclockwise* direction *increases* the sensitivity. The signal voltage is equal to the number of lines of deflection of the pen trace from the pen zero, multiplied by the VOLTS/LINE setting.

MEDIUM GAIN—SINGLE ENDED INPUT

For Medium gain, single ended input operation, complete the preliminary setup as explained in the first 10 steps of the "OPERATING PROCEDURE" and proceed as follows:

1. Turn the INPUT SELECTOR to the MEDIUM GAIN-SINGLE position.
2. Connect the amplifier to an appropriate power source.
3. Turn the POWER OFF-ON switch to "ON". Allow amplifier 10 to 15 minutes to warm up.
4. Turn the oscillograph to "ON". Zero the pen in the center of the chart paper by means of the PEN ZERO control.
5. Depress RIGHT CALIBRATE switch and adjust RIGHT CALIBRATE-20 LINES control for 20 lines of pen deflection.
6. Release RIGHT CALIBRATE switch.
7. Connect the signal input to the amplifier by means of either the front panel (GR) terminals or the rear panel (AN) connector. When connecting a single ended input signal at the front panel, the "hot" side (in reference to ground) must be connected to the MEDIUM GAIN-INPUT 2 terminal and the side of the circuit to be grounded to the MEDIUM GAIN-INPUT 1 terminal. If the rear panel input connector is used, the "hot" side of the signal (in reference to ground) must be connected to pin "C" and the ground connected to pin "B" of the AN connector.
8. Adjust the VOLTS/LINE selector to desired sensitivity. Each successive step in a *counterclockwise* direction *increases* the sensitivity. The signal voltage is equal to the number of lines of deflection of the pen trace from the pen zero, multiplied by the VOLTS/LINE setting.

HIGH GAIN—SINGLE ENDED INPUT

For high gain, single ended input operation, complete the preliminary setup as explained in the first 10 steps of the "OPERATING PROCEDURE" and proceed as follows:

1. Turn the INPUT SELECTOR to the HIGH GAIN position.
2. Connect the amplifier to an appropriate power source.
3. Turn the POWER OFF-ON switch to "ON". Allow the amplifier 10 to 15 minutes to warm up.
4. Place an open shielded GR type connector (supplied with the amplifier) over the HIGH GAIN INPUT terminals using care to match the "G" of the connector to the "GND" (ground) of the terminals.
5. Turn the MILLIVOLTS/LINE switch as far as possible in a *counterclockwise* direction to position marked ".1" on the panel.

   NOTE: For maximum accuracy, calibration must be made at the .1 position. The first three attenuator steps are connected to the output of the high gain section. Thus output from the calibration signal is also reduced by the attenuator; i.e., the signal calibrated for 20 lines with the millivolts/line switch in the .1 position, will reduce to 10 lines in the .2 position; to 4 lines in the .5 position and to 2 lines when in positions 1 to 20.
6. Turn OPERATE SWITCH to position marked "ZERO".
7. Turn the oscillograph to "ON." Adjust pen trace to the center line of the chart paper by means of the PEN ZERO control.
8. Turn OPERATE SWITCH to BALANCE position.
9. By means of the BALANCE CONTROL again adjust the pen trace to *approximately* the center line of the chart paper. With the OPERATE SWITCH in the BALANCE position the correction circuit of the high gain section of the amplifier is disconnected. Therefore the amplifier's inherent drift will be indicated on the chart paper. The purpose of the BALANCE CONTROL is to adjust the amplifier to only an approximately balanced condition so that the amplifier need correct for only a small error.

10. Turn OPERATE SWITCH to the ZERO position and check the pen trace in relation to the center line of the chart paper. If pen does not center on the chart paper, re-adjust with the PEN ZERO control.
11. Turn OPERATE SWITCH to the OPERATE position. Note: Because of the high sensitivity of the amplifier in this operating condition, it must be protected from all stray noise pickup.
12. Depress LEFT CALIBRATE switch and adjust LEFT CALIBRATE-20 LINES control for an overall total of 20 lines of pen deflection.
13. Release LEFT CALIBRATE switch.
14. If pen trace does not return to the zero line, but is off *less* than 1 line of chart paper, re-adjust to the zero line by means of the PEN ZERO control. If the pen trace is *more* than 1 line off the center line of the chart paper, center the pen trace on the chart paper by means of the GRID CURRENT adjustment on the rear panel of the amplifier. See ROUTINE ADJUSTMENT and MAINTENANCE.
15. Turn MILLIVOLTS/LINE switch to "OFF".
    NOTE: The above step is very important before continuing with the next step.
16. Remove the open shielded GR type connector previously placed across the HIGH GAIN INPUT terminals. (Step 4, above.)
17. Connect the desired input signal to the HIGH GAIN INPUT terminals by means of a *shielded* GR *type connector.*
18. Advance the MILLIVOLTS/LINE switch in a *counterclockwise* direction to the desired operating position. The signal voltage is equal to the number of lines of deflection of the pen trace from the pen zero position, multiplied by the MILLIVOLTS/LINE setting.

When operating in the High Gain position, the pen trace may be moved from the center line of the chart paper to any arbitrary position on the chart paper by means of the PEN ZERO control. This arbitrary position becomes the zero reference line.

OFF-CENTER ZERO OPERATION
(When using medium gain section with single ended input only)

Under certain conditions, more complete information regarding the dynamic component of a complex signal is required. It is possible, by adjusting the zero position of the signal off the chart paper, to cancel the static component and magnify the amplitude of the recording of the dynamic component. After placing the INPUT SELECTOR in the MEDIUM GAIN-SINGLE position, display the signal on an appropriate VOLTS/LINE setting, using either the front panel (GR) MEDIUM GAIN INPUT terminals or the rear panel (AN) connector. Zero the pen on the center line of the chart paper by means of the PEN ZERO control and turn the VOLTS/LINE switch to the next lower setting. Follow this by turning the PEN ZERO control until the pen records equal amplitude of the dynamic signal component on either side of the center line of the chart paper. *Note: This step is particularly important.* The above procedure may be repeated until the dynamic signal amplitude is as great as possible without exceeding 40 lines (peak to peak) of the chart paper or until the d.c. (static component) center shift is 200 lines off chart center. This is the maximum available shift off chart center, obtainable by adjustment of the PEN ZERO control (to either extreme of its rotation) at any VOLTS/LINE switch position. The peak to peak voltage of the signal under observation is equal to the number of chart lines (peak to peak) multiplied by the setting of the VOLTS/LINE switch.
NOTE: No off-center zero operation is possible with the medium gain section in a balanced operation.

OFF-CENTER ZERO OPERATION
(When using the high gain section only)

The maximum off-center zero range possible with the single ended high gain section is as follows:

MILLIVOLTS/LINE SETTING	MAXIMUM ZERO SUPPRESSION
.1	200 lines
.2	200 lines
.5	100 lines
1	50 lines
2	50 lines
5	50 lines
10	50 lines
20	50 lines

ROUTINE ADJUSTMENT and MAINTENANCE

This amplifier has been accurately balanced and adjusted before shipment from the factory and should give long, trouble-free service. This amplifier is normally wired to operate with from 105 to 125 volts input. If however, the prevailing power supply is from 95 to 115 volts, a slight modification of the wiring of the power transformer (T-1) will accommodate this condition. See Tube Layout (Fig. 2) and the schematic wiring diagram. To make this modification disconnect the input power lead and the capacitor lead from terminal "3" of the power transformer. Re-connect these same two leads to terminal "2" of the same transformer. The lead which connects terminal "3" to the separate filament transformer (T-2) should be re-soldered on terminal "3" of the power transformer (T-1). This modification will be made at the factory, if requested at time of ordering. For any servicing except the above modification and tube replacement, the instrument should be sent back to the factory where facilities are available to restore it to its original condition. See inside the title page for shipping instructions.

NOTE: The left side chassis (the high gain amplifier) has five (5) soldered connections which may be serviced in the field only by means of special solder, special soldering equipment and special soldering technique. They may be identified on the chassis by the green with which they are painted. They are

also identified on the schematic wiring diagram. If these connections must be broken and resoldered, special solder for this purpose is available from the Brush Electronics Company, Customer Service Department.

TUBE REPLACEMENT

To replace any faulty tube, begin by disconnecting all cables and expose the chassis. If the amplifier is portable case mounted, remove the top and bottom screws as well as the four screws on the front panel and withdraw the amplifier. If the amplifier is rack mounted, remove from the rack and take off the top portion of the wrap-around cover. In either case all tubes will be exposed.

Right Side Chassis

If any of the 5687's or the 12AT7WA's are replaced, proceed as follows:

1. Remove the 5751 (V-7) tube from the right side chassis (see Fig. 2). IMPORTANT: This tube remains out during adjustment, regardless of which tube of the pen drive amplifier was replaced.
2. Warm up amplifier (10 to 15 minutes).
3. Connect the oscillograph to an appropriate power source.
4. Turn "ON" the oscillograph and center the pen by means of the pen centering lever.
5. Connect amplifier to oscillograph and with the oscillograph connected and operating, adjust pen to zero (center line) of the chart paper, by means of the adjustment control on the back panel marked "TUBE ADJ" (tube adjustment). This operation balances the medium gain d.c. section of the right side chassis of the amplifier.
6. Replace the 5751 tube previously removed. Zero pen by means of PEN ZERO control.
7. If it is necessary to replace either the 5751 or the 3TF4 tubes, no adjustment is necessary.

Power Supply Chassis

Following the replacement of any tube in this section (Fig. 2) the +B voltage must be checked and adjusted. The voltage between the case of the condenser C-31, and pin 5 of the 0A2 tube (V-16), must be adjusted to 213 volts (± 5 volts) by means of the control (R-142).

Left Side Chassis

If any tubes are replaced in the left side chassis, it will be necessary to re-balance this section. To re-balance this section, expose the chassis as explained under "Tube Replacement" and proceed as follows:

1. Replace the faulty tube.
2. Connect the amplifier to an appropriate power source.
3. Warm up amplifier (10 to 15 minutes).
4. Turn INPUT SELECTOR to HIGH GAIN position.

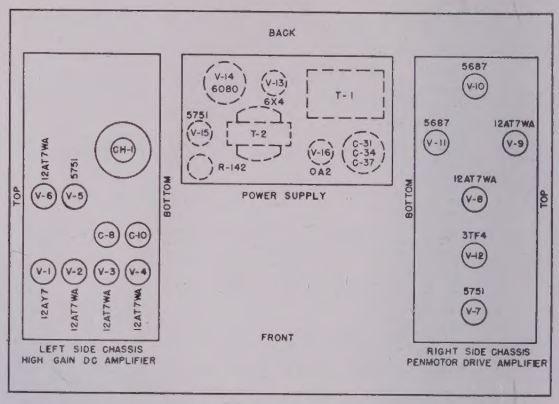

Fig. 2. Tube Layout.

5. Turn OPERATE SWITCH to ZERO position.
6. Connect oscillograph to appropriate power source.
7. Turn oscillograph to "ON" and adjust pen to center line of chart paper by means of the PEN ZERO control.
8. Turn oscillograph to "OFF".
9. Place an open, shielded GR type connector (supplied with the amplifier) over the HIGH GAIN INPUT terminals, using care to match the "G" of the connector to the "GND" (ground) of the terminals.
10. Turn LEFT CALIBRATE-20 LINES control fully clockwise.
11. Turn the MILLIVOLTS/LINE switch to the .1 position.
12. Turn OPERATE SWITCH to BALANCE position.
13. By means of a DC voltmeter (V.T.V.M.), meassure the d.c. voltage from chassis (ground) to pin 1 and from chassis to pin 6 of the 12AT7WA (V-4) tube. See Tube Layout—Fig. 2. If amplifier is balanced the voltage will be zero (0) and no further adjustment is necessary. If not, continue as described below.
14. By means of the BALANCE CONTROL on the front panel of the amplifier, adjust for equal d.c. voltage readings in step 13, above.
15. By means of the PLATE ADJ (plate adjustment) on the rear of the amplifier, adjust the d.c. voltage reading between the chassis and pin 1 in step 13, above, to zero (0), ± 1 volt.
16. Repeat steps 13, 14, and 15, above, until the d.c. voltmeter readings from chassis to pin 1 and from chassis to pin 6 of the 12AT7WA (V-4) tube are zero (0), ± 1 volt. This may have to be repeated.
17. Restore the wrap-around cover or replace the instrument in its portable case. (This is to prevent pickup of stray noise.)
18. Connect amplifier to oscillograph.
19. Turn oscillograph to "ON" and adjust pen to approximately center line of chart paper by means of the BALANCE CONTROL on the front of the amplifier.
20. Depress the LEFT CALIBRATE switch several times. The deflection of the pen trace must

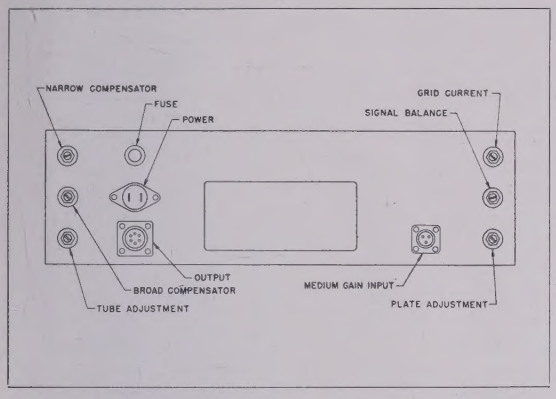

Fig. 3. Rear Panel of Amplifier.

average in excess of 20 lines of chart paper. OBSERVE THIS AVERAGE AS IT WILL BE USED LATER FOR REFERENCE. (If the deflection of the pen averages less than 20 lines, check the voltage of the internal mercury cell with an accurate voltmeter. It must be 1.35 volts ± 1%.)

21. Turn OPERATE SWITCH to OPERATE position.
22. Displace pen trace to left side of chart paper by means of the PEN ZERO control.
23. Depress LEFT CALIBRATE switch and adjust pen trace to the same number of lines of pen deflection as observed in step 20 above, by means of the SIGNAL BAL (signal balance) control on the rear of the amplifier.
24. Restore the pen trace to the center line of the chart paper by means of the PEN ZERO control.
25. Turn OPERATE SWITCH to the BALANCE position.
26. Center the pen trace *approximately* on the center line of the chart paper by means of the BALANCE CONTROL.
27. Turn OPERATE SWITCH to ZERO position.
28. If necessary, restore the pen trace to the center line of the chart paper by means of the PEN ZERO control.
29. Turn OPERATE SWITCH to the OPERATE position.
30. Depress LEFT CALIBRATE switch and adjust to 20 lines of pen deflection by means of the LEFT CALIBRATE-20 LINES control.
31. Center the pen trace on the chart paper by means of the GRID CURRENT adjustment on the rear of the amplifier.
32. Re-calibrate for 20 lines of pen deflection by means of the LEFT CALIBRATE-20 LINES control. It may be necessary to repeat the above steps 25 through 32.

FREQUENCY COMPENSATION

To obtain optimum frequency response of an amplifier-oscillograph combination, the frequency response of the amplifier must be adjusted to match the penmotor of the oscillograph. (When an amplifier and an oscillograph are purchased together, this adjustment is made at the factory.)

To match an amplifier to an oscillograph, proceed as follows:

1. Turn INPUT SELECTOR to the MEDIUM GAIN-SINGLE position.
2. Warm up amplifier (10 to 15 minutes).
3. Adjust pen pressure of oscillograph with a gram gage. (See Operating Instructions for the Oscillograph.)
4. Connect an oscillator covering the range from 10 to 100 cps to either the front panel (GR) MEDIUM GAIN-INPUT terminals or the rear panel (AN) connector. Pin "A" is the ground and pin "C" is the "active" terminal on the rear connector.
5. Turn BROAD COMP (broad compensator) switch *fully counterclockwise.*
6. At 10 cps adjust oscillator output level for 10 lines total pen deflection (peak to peak). Note: The pen deflection is a product of the oscillator output voltage, the VOLTS/LINE setting and the setting of the RIGHT CALIBRATE-20 LINES control. Observe the oscillator output voltage as it is the reference voltage and must remain constant during the frequency compensation.
7. At 100 cps (with oscillator output voltage the same as in step 6, above) adjust the NARROW COMP (narrow compensator) for maximum pen deflection. If maximum pen deflection thus obtained is less than 10 lines, advance the BROAD COMP (broad compensator) *clockwise* by steps until the maximum pen deflection obtainable by adjustment of the NARROW COMP (narrow compensator) is at least 10 lines. (If extreme or erratic pen deflections are observed, the condition is due to internal oscillations within the amplifier. This is corrected by turning slightly the NARROW COMP in a *counterclockwise* direction until the condition ceases.)
8. If maximum pen deflection thus obtained is over 10 lines, adjust the NARROW COMP (narrow compensator) *counterclockwise* until a pen deflection of 10 lines is obtained. Test for flatness of response from 100 to 10 cps.
9. Re-set input voltage at 100 cps as in step 7, above. Adjust NARROW COMP (narrow compensator) *clockwise* through the maximum pen deflections until a pen deflection of 10 lines is again obtained. Again test for flatness of response of from 100 to 10 cps.
10. The best frequency response of the amplifier-oscillograph combination will be either that obtained in step 8 or step 9. This selection may be determined by comparing the two graphs.

NOTE: In cases where extended frequency response is desired (when the amplifier is being used with an oscilloscope or for similar application) turn the BROAD COMP (broad compensator) control fully clockwise.

PARTS LIST

Symbol	Description	Value	Brush Part No.
B-1	Mercury Cell	1.35 V, ± 1%	2-119701-1
C-1	Capacitor, Mica	30 mmfd, ± 5%, 500 V	5-117264-300
C-2	Capacitor, Mica	30 mmfd, ± 5%, 500 V	5-117264-300
C-3	Capacitor, Mica	220 mmfd, ± 5%, 500 V	5-117264-221
C-4	Capacitor, Paper	.02 mfd, ± 10%, 400 V	10-120555-203
C-5	Capacitor, Electrolytic	8 mfd, 450 V	100-120470-805
C-6	Capacitor, Paper	.05 mfd, ± 10%, 400 V	10-120555-503
C-7	Capacitor, Paper	.001 mfd, ± 10%, 600 V	10-217260-102
C-8	Capacitor, Electrolytic	20 mfd, 450 V	117717-206
C-9	Capacitor, Paper	.05 mfd, ± 10%, 400 V	10-120555-503
C-10	Capacitor, Electrolytic	20 mfd, 450 V	117717-206
C-11	Capacitor, Paper	.05 mfd, ± 10%, 400 V	10-120555-503
C-12	Capacitor, Mica	.001 mfd, ± 5%, 500 V	5-117265-102
C-13	Capacitor, Paper	2 mfd, ± 10%, 200 V	10-120554-205
C-14	Capacitor, Mica	220 mmfd, ± 5%, 500 V	5-119621-221
C-15	Capacitor, Mica	330 mmfd, ± 5%, 500 V	5-119621-331
C-16	Capacitor, Mica	.001 mfd, ± 5%, 500 V	5-117264-102
C-17	Capacitor, Mica	.001 mfd, ± 5%, 500 V	5-117264-102
C-18	Capacitor, Paper	2 mfd, ± 10%, 200 V	10-120554-205
C-19	Capacitor, Mica	470 mmfd, ± 5%, 500 V	5-117264-471
C-20	Capacitor, Mica	.001 mfd, ± 5%, 500 V	5-117264-102
C-21	Capacitor, Mica	.001 mfd, ± 5%, 500 V	5-117264-102
C-22	Capacitor, Mica	.001 mfd, ± 5%, 500 V	5-117264-102
C-23	Capacitor, Mica	.001 mfd, ± 5%, 500 V	5-117264-102
C-24	Capacitor, Mica	.001 mfd, ± 5%, 500 V	5-117264-102
C-25	Capacitor, Mica	470 mmfd, ± 5%, 500 V	5-117264-471
C-26	Capacitor, Mica	680 mmfd, ± 5%, 500 V	5-117264-681
C-27	Capacitor, Mica	.0015 mfd, ± 5%, 500 V	5-117265-152
C-28	Capacitor, Mica	.0022 mfd, ± 5%, 500 V	5-117265-222
C-29	Capacitor, Paper	.01 mfd, ± 10%, 600 V	10-217260-103
C-30	Capacitor, Paper	.01 mfd, ± 10%, 600 V	10-217260-103
C-31	Capacitor, Electrolytic (⅓ triple section)	20 mfd, 450 V	117718-206
C-32	Capacitor, Paper	.01 mfd, ± 10%, 400 V	10-217413-103
C-33	Capacitor, Mica	.0022 mfd, ± 10%, 500 V	10-117265-222
C-34	Capacitor, Electrolytic (⅓ triple section)	20 mfd, 450 V	(See C-31)
C-35	Capacitor, Paper	.25 mfd, 200 V	10-120554-254
C-36	Capacitor, Electrolytic	100 mfd, 150 V	100-117681-107
C-37	Capacitor, Electrolytic (⅓ triple section)	20 mfd, 450 V	(See C-31)
C-38	Capacitor, Mica	.01 mfd, ± 5%, 500 V	5-117265-103
C-39	Capacitor, Electrolytic	1000 mfd, 15 V	100-120596-108
C-40	Capacitor, Electrolytic (½ dual section)	1000 mfd, 15 V	100-120471-108
C-41	Capacitor, Electrolytic (½ dual section)	1000 mfd, 15 V	(See C-40)
CH-1	Chopper		120379-1
E-1	Lamp, Incandescent	Type 51	105796-1
F-1	Fuse, 2 Amp, 250V	Type 3AG	102625
FL-1	Filter, Power Line		123361
J-1	Binding Post (2)	GR Type	119741-3
J-2	Binding Post (3)	GR Type	119741-3
J-3	Connector, Female	Strip Type	2-122555-2
J-4	Connector, Female	Strip Type	2-122555-5
J-5	Receptacle, Female	AN Type	119990
P-1	Receptacle, Male	AN Type	121274
P-2	Receptacle, Male		6526
R-1	Resistor, Precision	500 K, ±1%, ½ W	1-117802-5003
R-2	Resistor, Precision	1.0 M, ± 1%, ½ W	1-117802-1004
R-3	Resistor, Precision	800 K, ± 1%, ½ W	1-117802-8003
R-4	Resistor, Precision	250 K, ± 1%, ½ W	1-117802-2503
R-5	Resistor, Precision	900 K, ± 1%, ½ W	1-117802-9003
R-6	Resistor, Precision	58.5 K, ± 1%, ½ W	1-117802-5852

Symbol	Description	Value	Brush Part No.
R-7	Resistor, Precision	52.5 K, ± 1%, ½ W	1-117802-5252
R-8	Resistor, Precision	5.0 M, ± 1%, ½ W	1-117802-5004
R-9	Resistor, Precision	7.47 K, ± 1%, ½ W	1-117802-7471
R-10	Resistor, Variable	2.5 M	19-211473-255
R-11	Resistor, Composition	1.5 M, ± 5%, ½ W	5-115557-155
R-12	Resistor, Variable	2.5 M	19-211473-255
R-13	Resistor, Composition	22 M, ± 5%, ½ W	5-115557-226
R-14	Resistor, Composition	620 K, ± 5%, ½ W	5-115557-624
R-15	Resistor, Variable	500 ohms	10-120595-501
R-16	Resistor, Composition	220 K, ± 5%, ½ W	5-115557-224
R-17	Resistor, Composition	100 ohms, ± 5%, ½ W	5-115557-101
R-18	Resistor, Composition	100 ohms, ± 5%, ½ W	5-115557-101
R-19	Resistor, Composition	4.7 M, ± 5%, ½ W	5-115557-475
R-20	Resistor, Precision	250 K, ± 1%, ½ W	1-120366-25002
R-21	Resistor, Precision	1.2 K, ± 1%, ¼ W	1-120365-12000
R-22	Resistor, Precision	390 K, ± 1%, ½ W	1-120366-39002
R-23	Resistor, Precision	1.2 K, ± 1%, ¼ W	1-120365-12000
R-24	Resistor, Precision	250 K, ± 1%, ½ W	1-120366-25002
R-25	Resistor, Precision	2.5 M, ± 1%, 1 W	1-120363-25003
R-26	Resistor, Precision	500 K, ± 1%, ½ W	1-120366-50002
R-27	Resistor, Precision	500 K, ± 1%, ½ W	1-120366-50002
R-28	Resistor, Precision	2.5 M, ± 1%, 1 W	1-120363-25003
R-29	Resistor, Precision	100 K, ± 1%, ½ W	1-117802-1003
R-30	Resistor, Variable 10 Turn	2 K	119048
R-31	Resistor, Precision	15 K, ± 1%, ½ W	1-117802-1502
R-32	Resistor, Precision	100 K, ± 1%, ½ W	1-117802-1003
R-33	Resistor, Composition	1.2 M, ± 5%, ½ W	5-115557-125
R-34	Resistor, Precision	1.1 M, ± 1%, ½ W	1-117802-1104
R-35	Resistor, Precision	510 K, ± 1%, ½ W	1-117802-5103
R-36	Resistor, Precision	18 K, ± 1%, ½ W	1-117802-1802
R-37	Resistor, Precision	510 K, ± 1%, ½ W	1-117802-5103
R-38	Resistor, Precision	1.1 M, ± 1%, ½ W	1-117802-1104
R-39	Resistor, Composition	1.2 M, ± 5%, ½ W	5-115557-125
R-40	Resistor, Precision	100 K, ± 1%, ½ W	1-117802-1003
R-41	Resistor, Precision	1.1 M, ± 1%, ½ W	1-117802-1104
R-42	Resistor, Precision	300 K, ± 1%, ½ W	1-117802-3003
R-43	Resistor, Variable	25 K	4-211473-253
R-44	Resistor, Precision	300 K, ± 1%, ½ W	1-117802-3003
R-45	Resistor, Precision	1.1 M, ± 1%, ½ W	1-117802-1104
R-46	Resistor, Precision	100 K, ± 1%, ½ W	1-117802-1003
R-47	Resistor, Precision	100 K, ± 1%, ½ W	1-117802-1003
R-48	Resistor, Precision	100 K, ± 1%, ½ W	1-117802-1003
R-49	Resistor, Precision	33 K, ± 1%, ½ W	1-117802-3302
R-50	Resistor, Precision	33 K, ± 1%, ½ W	1-117802-3302
R-51	Resistor, Precision	900 K, ± 1%, ½ W	1-117802-9003
R-52	Resistor, Precision	2.0 M, ± 1%, ½ W	1-117802-2004
R-53	Resistor, Variable	10 K	10-120595-103
R-54	Resistor, Precision	2.0 M, ± 1%, ½ W	1-117802-2004
R-55	Resistor, Precision	900 K, ± 1%, ½ W	1-117802-9003
R-56	Resistor, Composition	4.7 M, ± 5%, ½ W	5-115557-475
R-57	Resistor, Composition	4.7 M, ± 5%, ½ W	5-115557-475
R-58	Resistor, Precision	250 K, ± 1%, ½ W	1-120366-25002
R-59	Resistor, Precision	10 K, ± 1%, ½ W	1-117802-1002
R-60	Resistor, Composition	1.0 M, ± 5%, ½ W	5-115557-105
R-61	Resistor, Composition	47 K, ± 5%, ½ W	5-115557-473
R-62	Resistor, Precision	250 K, ± 1%, ½ W	1-120366-25002
R-63	Resistor, Composition	8.2 K, ± 5%, ½ W	5-115557-822
R-64	Resistor, Composition	10 K, ± 5%, ½ W	5-115557-103
R-65	Resistor, Composition	1.0 M, ± 5%, ½ W	5-115557-105
R-66	Resistor, Composition	82 K, ± 5%, ½ W	5-115557-823
R-67	Resistor, Composition	2.2 K, ± 5%, ½ W	5-115557-222
R-68	Resistor, Composition	10 K, ± 5%, ½ W	5-115557-103
R-69	Resistor, Composition	1.0 M, ± 5%, ½ W	5-115557-105

Symbol	Description	Value	Brush Part No.
R-70	Resistor, Composition	1.0 M, ± 5%, ½ W	5-115557-105
R-71	Resistor, Composition	150 K, ± 5%, ½ W	5-115557-154
R-72	Resistor, Composition	2.2 K, ± 5%, ½ W	5-115557-222
R-73	Resistor, Composition	100 K, ± 5%, ½ W	5-115557-104
R-74	Resistor, Composition	10 M, ± 5%, ½ W	5-115557-106
R-75	Resistor, Composition	22M , ± 5%, ½ W	5-115557-226
R-76	Resistor, Precision	5.0 M, ± 1%, ½ W	1-117802-5004
R-77	Resistor, Precision	3.0 M, ± 1%, ½ W	1-117802-3004
R-78	Resistor, Precision	1.0 M, ± 1%, ½ W	1-117802-1004
R-79	Resistor, Precision	1.0 M, ± 1%, ½ W	1-117802-1004
R-80	Resistor, Precision	500 K, ± 1%, ½ W	1-117802-5003
R-81	Resistor, Precision	1.0 M, ± 1%, ½ W	1-117802-1004
R-82	Resistor, Precision	750 K, ± 1%, 1 W	1-117803-7503
R-83	Resistor, Precision	330 K, ± 1%, ½ W	1-117802-3303
R-84	Resistor, Precision	900 K, ± 1%, 1 W	1-117803-9003
R-85	Resistor, Precision	110 K, ± 1%, ½ W	1-117802-1103
R-86	Resistor, Precision	950 K, ± 1%, 1 W	1-117803-9503
R-87	Resistor, Precision	26 K, ± 1%, ½ W	1-117802-2602
R-88	Resistor, Precision	16.5 K, ± 1%, ½ W	1-117802-1652
R-89	Resistor, Precision	5.05 K, ± 1%, ½ W	1-117802-5051
R-90	Resistor, Precision	5.05 K, ± 1%, ½ W	1-117802-5051
R-91	Resistor, Composition	350 K, ± 5%, ½ W	5-115557-354
R-92	Resistor Assembly, Variable	1M, ± 0.5%	222362-501
R-93	Resistor, Precision	5.0 M, ± 1%, ½ W	1-117802-5004
R-94	Resistor, Precision	5.0 M, ± 1%, ½ W	1-117802-5004
R-95	Resistor, Precision	250 K, ± 1%, ½ W	1-117802-2503
R-96	Resistor, Precision	2.5 M, ± 1%, ½ W	1-117802-2504
R-97	Resistor, Precision	5.0 M, ± 1%, ½ W	1-117802-5004
R-98	Resistor, Composition	1.2 K, ± 5%, ½ W	5-115557-122
R-99	Resistor, Precision	250 K, ± 1%, ½ W	1-117802-2503
R-100	Resistor, Composition	1.2 K, ± 5%, ½ W	5-115557-122
R-101	Resistor, Precision	5.0 M, ± 1%, ½ W	1-117802-5004
R-102	Resistor, Precision	2.5 M, ± 1%, ½ W	1-117802-2504
R-103	Resistor, Precision	250 K, ± 1%, ½ W	1-117802-2503
R-104	Resistor, Precision	6.8 M, ± 1%, 1 W	1-117803-6804
R-105	Resistor, Precision	2.2 M, ± 1%, ½ W	1-117802-2204
R-106	Resistor, Precision	2.2 M, ± 1%, ½ W	1-117802-2204
R-107	Resistor, Precision	6.8 M, ± 1%, 1 W	1-117803-6804
R-108	Resistor, Composition	100 K, ± 5%, ½ W	5-115557-104
R-109	Resistor, Composition	3.6 K, ± 5%, ½ W	5-115557-362
R-110	Resistor, Variable	3 K, ± 20%, ½ W	20-125156-302
R-111	Resistor, Composition	3.6 K, ± 5%, ½ W	5-115557-362
R-112	Resistor, Composition	100 K, ± 5%, ½ W	5-115557-104
R-113	Resistor, Precision	1.1 M, ± 1%, ½ W	1-117802-1104
R-114	Resistor, Precision	510 K, ± 1%, ½ W	1-117802-5103
R-115	Resistor, Composition	11 K, ± 5%, ½ W	5-115557-113
R-116	Resistor, Precision	510 K, ± 1%, ½ W	1-117802-5103
R-117	Resistor, Precision	1.1 M, ± 1%, ½ W	1-117802-1104
R-118	Resistor, Composition	100 K, ± 5%, ½ W	5-115557-104
R-119	Resistor, Precision	1.72 M, ± 1%, ½ W	1-117802-1724
R-120	Resistor, Precision	470 K, ± 1%, ½ W	1-117802-4703
R-121	Resistor, Composition	18 K, ± 5%, ½ W	5-115557-183
R-122	Resistor, Precision	470 K, ± 1%, ½ W	1-117802-4703
R-123	Resistor, Precision	1.72 M, ± 1%, ½ W	1-117802-1724
R-124	Resistor, Composition	100 K, ± 5%, ½ W	5-115557-104
R-125	Resistor, Composition	1.1 K, ± 5%, 2 W	5-115559-112
R-126	Resistor, Composition	680 ohms, ± 5%, ½ W	5-115557-681
R-127	Resistor, Composition	2.2 M, ± 5%, ½ W	5-115557-225
R-128	Resistor, Composition	1.0 M, ± 5%, ½ W	5-115557-105
R-129	Resistor, Composition	1.0 M, ± 5%, ½ W	5-115557-105
R-130	Resistor, Variable	1.0 M	19-211473-105
R-131	Resistor, Composition	1.0 M, ± 5%, ½ W	5-115557-105
R-132	Resistor, Composition	1.0 M, ± 5%, ½ W	5-115557-105

Symbol	Description	Value	Brush Part No.
R-133	Resistor, Composition	2.2 M, ± 5%, ½ W	5-115557-225
R-134	Resistor, Composition	68 ohms, ± 5%, 1 W	5-115558-680
R-135	Resistor, Composition	68 ohms, ± 5%, 1 W	5-115558-680
R-136	Resistor, Composition	100 ohms, ± 5%, ½W	5-115557-101
R-137	Resistor, Precision	1.0 M, ± 1%, ½ W	1-117802-1004
R-138	Resistor, Precision	5.0 M, ± 1%, ½ W	1-117802-5004
R-139	Resistor, Precision	5.0 M, ± 1%, ½ W	1-117802-5004
R-140	Resistor, Precision	1.0 M, ± 1%, ½ W	1-117802-1004
R-141	Resistor, Precision	390 K, ± 1%, ½ W	1-117802-3903
R-142	Resistor, Variable	100 K	19-211473-104
R-143	Resistor, Precision	150 K, ± 1%, ½ W	1-117802-1503
R-144	Resistor, Composition	220 K, ± 5%, ½ W	5-115557-224
R-145	Resistor, Composition	10 K, ± 5%, 2 W	5-115559-103
R-146	Resistor, Composition	27 K, ± 5%, 1 W	5-115558-273
R-147	Resistor, Composition	18 K, ± 5%, 1 W	5-115558-183
R-148	Resistor, Composition	330 K, ± 5%, ½ W	5-115557-334
R-149	Resistor, Composition	220 K, ± 5%, ½ W	5-115557-224
R-150	Resistor, Precision	75 K, ± 1%, 1 W	1-117803-7502
R-151	Resistor, Precision	9.1 K, ± 1%, ½ W	1-117802-9101
R-152	Resistor, Precision	9.1 K, ± 1%, ½ W	1-117802-9101
R-153	Resistor, Precision	50 K, ± 1%, 1 W	1-117803-5002
R-154	Resistor, Variable 10 Turn	50 K	121080
R-155	Resistor, Composition	1 M, ± 5%, ½ W	5-115557-105
R-156	Resistor, Composition	1 ohm, ± 10%, 2 W	10-115556-1R0
S-1	Switch, Rotary		221131
S-2	Switch, Toggle, Momentary		124334
S-3	Switch, Rotary		121042
S-4	Switch, Rotary		119652
S-5	Switch, Toggle, Momentary		124334
S-6	Switch, Rotary		121042
S-7	Switch, Rotary		118828
S-8	Switch, Rotary		119052-1
SR-1	Rectifier, Metallic		120387-17
T-1	Transformer, Power		121553
T-2	Transformer, Filament		124256
V-1	Tube, Electron 12AY7		109966
V-2	Tube, Electron 12AT7WA		122813
V-3	Tube, Electron 12AT7WA		122813
V-4	Tube, Electron 12AT7WA		122813
V-5	Tube, Electron 5751		119028
V-6	Tube, Electron 12AT7WA		122813
V-7	Tube, Electron 5751		119028
V-8	Tube, Electron 12AT7WA		122813
V-9	Tube, Electron 12AT7WA		122813
V-10	Tube, Electron 5687		122828
V-11	Tube, Electron 5687		122828
V-12	Tube, Ballast 3TF4		119373
V-13	Tube, Electron 6X4		117614
V-14	Tube, Electron 6080		115267
V-15	Tube, Electron 5751		119028
V-16	Tube, Electron 0A2		107098
	Connector, Shielded, Open	GR Type	103503
	Cable, Signal		223385-501
	Cable, Power		117630
	Solder, Special Purpose		122984

TUBE SOCKET PIN VOLTAGES

1. Voltages should be measured under the following conditions:
   a. LEFT CALIBRATE-20 LINES control fully counterclockwise.
   b. MILLIVOLTS/LINE attenuator in "OFF" position.
   c. INPUT SELECTOR switch at "MEDIUM GAIN—SINGLE" position.
   d. RIGHT CALIBRATE-20 LINES control fully counterclockwise.
   e. 1500 ohm resistor connected across output terminals (pins "B" and "C" of output connector).
   f. Voltage across output resistor adjusted to zero (0 volts) by means of the PEN ZERO control.
2. D.C. measurements should be made with a DC voltmeter with a minimum of ten (10) megohms input impedance.
3. A.C. voltages should be measured with an accurate RMS AC voltmeter (20,000 ohms per volt or higher).
4. The +B voltage should be adjusted to 213 volts as described in the Operating Instructions under "ROUTINE ADJUSTMENT AND MAINTENANCE—Power Supply Chassis."
5. All measurements should be made from the tube pin to —B (⏚) point, except where otherwise noted.
6. Variations in observed voltage readings from tabulated values do not necessarily indicate improper operation unless deviations exceed 10%.

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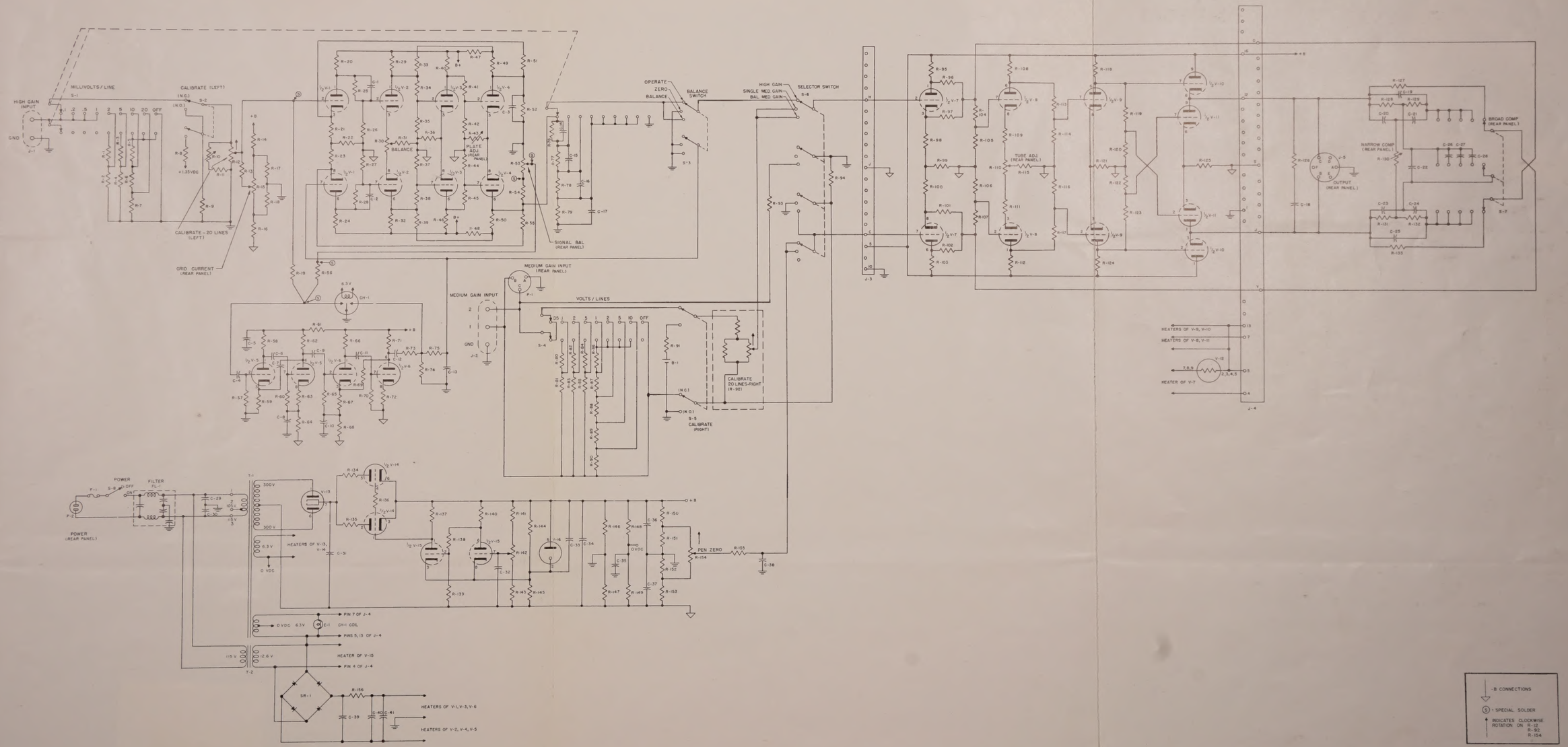
TUBE No.	TYPE	PIN NUMBER								
		1	2	3	4	5	6	7	8	9
V-1	12AY7	170	86	88	Note 1		170	86	88	—
V-2	12AT7WA	110	Note 5	30	Note 1		110	Note 5	30	—
V-3	12AT7WA	105	Note 5	36	Note 1		105	Note 5	36	—
V-4	12AT7WA	86	Note 5	23	Note 1		86	Note 5	23	—
V-5	5751	170	86	87	Note 1		145	2	4	—
V-6	12AT7WA	145	9	11	Note 1		100	0	2	—
V-7	5751	165	86	88	Note 2		165	86	88	—
V-8	12AT7WA	110	Note 5	29	Note 3		110	Note 5	29	—
V-9	12AT7WA	110	Note 5	36	Note 3		110	Note 5	36	—
V-10	5687	213	110	113	Note 4		113	110	—	213
V-11	5687	113	23	26	Note 4		26	23	—	113
V-13	6X4	—	—	—	—	—	—	—	—	—
V-14	6080	—	—	—	—	—	—	—	—	—
V-15	5751	Note 5		65	Note 3		Note 5		65	—
V-16	OA2	—	65	—	—	213	—	—	—	—

NOTES:

1. 4.3 to 4.7 volts DC measured from pins 4 and 5 to pin 9.
2. 4.4 to 5.8 volts AC measured from pins 4 and 5 to pin 9.
3. 6.3 volts AC measured from pins 4 and 5 to pin 9.
4. 6.3 volts AC measured from pins 4 and 5 to pin 8.
5. Do not measure.

BRUSH ELECTRONICS COMPANY
3405 PERKINS AVE. • CLEVELAND 14, OHIO • U.S.A.
Division of Clevite Corporation
Instrument Department
INDUSTRIAL AND RESEARCH INSTRUMENTS • PIEZOELECTRIC MATERIALS • ACOUSTIC DEVICES
MAGNETIC RECORDING EQUIPMENT AND COMPONENTS


MILLIVOLTS / LINE
HIGH GAIN INPUT
GND
CALIBRATE (LEFT)
CALIBRATE - 20 LINES (LEFT)
GRID CURRENT (REAR PANEL)
BALANCE
PLATE ADJ. (REAR PANEL)
SIGNAL BAL (REAR PANEL)
OPERATE
ZERO
BALANCE
BALANCE SWITCH
HIGH GAIN
SINGLE MED GAIN
BAL. MED GAIN
SELECTOR SWITCH
MEDIUM GAIN INPUT (REAR PANEL)
MEDIUM GAIN INPUT
VOLTS / LINES
CALIBRATE 20 LINES-RIGHT (R-98)
CALIBRATE (RIGHT)
TUBE ADJ. (REAR PANEL)
BROAD COMP (REAR PANEL)
NARROW COMP (REAR PANEL)
OUTPUT (REAR PANEL)
HEATERS OF V-9, V-10
HEATERS OF V-8, V-11
HEATER OF V-7
POWER
FILTER
POWER (REAR PANEL)
HEATERS OF V-13, V-14
PEN ZERO
PIN 7 OF J-4
CH-1 COIL
PINS 5, 13 OF J-4
HEATER OF V-15
PIN 4 OF J-4
HEATERS OF V-1, V-3, V-6
HEATERS OF V-2, V-4, V-5
-B CONNECTIONS
SPECIAL SOLDER
INDICATES CLOCKWISE ROTATION ON R-12 R-92 R-154

MP MASTER
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